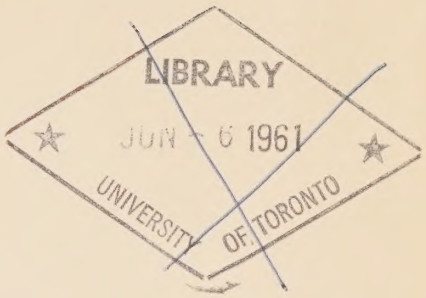
Canada. Interdepartmental
Skilled Manpower Training
Research Committee
Report

Government
Publications

RESEARCH PROGRAM ON THE
TRAINING OF
SKILLED MANPOWER



No. 2

TECHNOLOGICAL CHANGES AND SKILLED MANPOWER: ELECTRICAL AND ELECTRONICS INDUSTRY HEAVY MACHINERY INDUSTRY

Department of Labour, Canada,
in co-operation with federal and
provincial government agencies and
other groups

Reports Issued by the Interdepartmental Skilled Manpower Training Research Committee

No. 1 Progress Report (1957).

No. 2 Technological Changes and Skilled Manpower: Electrical and Electronics Industry and Heavy Machinery Industry (1957).

No. 3 Technological Changes and Skilled Manpower: The Household Appliance Industry (1958).

No. 4 Acquisition of Skills: A Study of the Education and Training Background of a Sample of Tool and Die Makers, Sheet Metal Workers, Floor Moulders, Draughtsmen and Electronic Technicians (1960).

No. 5A Vocational Training Programs in Canada - Technical and Trade Training - Publicly Operated (1958).

No. 5B Vocational Training Programs in Canada - Commercial, Service, and Other Occupations - Publicly Operated (1959).

No. 5C Vocational Training Programs in Canada - Agriculture - Publicly Operated (1959).

No. 6 Outline of Technical Training in the United Kingdom (1958).

Research Program on the
Training of Skilled Manpower

2 - TECHNOLOGICAL CHANGES AND SKILLED MANPOWER: SUMMARY REPORT ON THE ELECTRICAL AND ELECTRONICS INDUSTRY AND THE HEAVY MACHINERY INDUSTRY

Department of Labour, Canada,
in co-operation with federal and
provincial government agencies and
other groups

August 1957, Reprinted 1960

INTERDEPARTMENTAL SKILLED MANPOWER TRAINING RESEARCH COMMITTEE

List of Members

Department of Labour:

Mr. George V. Haythorne (Chairman),
Assistant Deputy Minister.

Mr. W. R. Dymond, Director,
Economics and Research Branch.

Mr. J. P. Francis, Chief,
Manpower Division,
Economics and Research Branch.

Mr. Phillip Cohen (Secretary),
Economics and Research Branch.

Mr. C. R. Ford, Director,
Vocational Training Branch.

Mr. R. H. MacCuish,
Vocational Training Branch.

Mr. D. E. Bridge,
Vocational Training Branch.

Miss Marion Royce, Director,
Women's Bureau.

Mr. Ian Campbell, National Co-ordinator,
Civilian Rehabilitation Branch.

Unemployment Insurance Commission:

Mr. W. Thomson, Director,
Employment Branch.

Mr. T. A. Fishbourne, Chief,
Employment Specialists Division,
National Employment Service.

National Research Council:

Mr. F. L. W. McKim,
Division of Administration.

Mr. E. H. Stock,
Personnel Services.

Defence Research Board:

Dr. H. W. Jamieson,
Directorate of Personnel,
Administration Branch.

Dominion Bureau of Statistics:

Dr. F. E. Whitworth, Director,
Education Division.

Mr. J. M. Grandbois,
Education Division.

THE ADVISORY COMMITTEE ON TECHNOLOGICAL CHANGE

List of Members

Mr. George V. Haythorne (Chairman),
Assistant Deputy Minister,
Department of Labour, Ottawa.

Mr. Gordon G. Cushing,
Assistant Deputy Minister,
Department of Labour, Ottawa.

Mr. D. R. Brown, Manager,
Employee and Community Relations Dept.,
Canadian General Electric Co. Ltd.,
Peterborough, Ontario.

Mr. Lloyd Hemsworth, Personnel Manager,
Employee Relations Department,
Canadian Industries Ltd.,
Montreal, Quebec.

Mr. R. B. Reddoch,
Industrial Relations Advisor,
General Motors of Canada Ltd.,
Oshawa, Ontario.

Mr. George Burt, Vice-President,
Canadian Labour Congress and
Canadian Director, Region No. 7,
United Automobile Workers,
Windsor, Ontario.

Mr. George P. Schollie, Vice-President,
Canadian Labour Congress and
Canadian Vice-President,
International Association of
Machinists,
Montreal, Quebec.

Dr. Eugene Forsey, Research Director,
Canadian Labour Congress,
Ottawa, Ontario.

Professor William Bruce, Chairman,
Department of Mechanical Engineering,
McGill University,
Montreal, Quebec.

Dr. B. G. Ballard, Vice-President,
(Scientific),
National Research Council,
Ottawa, Ontario.

Mr. W. Thomson, Director,
National Employment Service,
Ottawa, Ontario.

Mr. C. R. Ford, Director,
Canadian Vocational Training Branch,
Department of Labour,
Ottawa, Ontario.

Mr. W. R. Dymond, Director,
Economics and Research Branch,
Department of Labour,
Ottawa, Ontario.

Secretariat

Mr. J. P. Francis, Chief,
Manpower Resources Division,
Economics and Research Branch,
Department of Labour,
Ottawa, Ontario.

Mr. Phillip Cohen, Head,
Training Research Section,
Economics and Research Branch,
Department of Labour,
Ottawa, Ontario.

F O R E W O R D

This report is one of a series of studies carried out under the Skilled Manpower Training Research Program initiated by the federal Department of Labour in 1956, in co-operation with other interested federal and provincial departments and management and union organizations. The research program is under the general direction of the Interdepartmental Skilled Manpower Training Research Committee and its aims and objectives are set out in detail in Report No. 1 of this series, entitled "Progress Report", issued in June 1957.

An important phase of the Skilled Manpower Training Research Program has been the study of technological changes in selected industries and their effects on manpower and training requirements. In this phase of the program, the Committee has been greatly assisted by the tripartite Advisory Committee on Technological Change, which was set up in 1957.

The field work on which this report is based was undertaken in the summer of 1956 by Professor William Bruce of McGill University and Professor W. G. McIntosh of the University of Toronto. This report was prepared by Mr. F. W. Burton of the Economics and Research Branch of the Department of Labour.

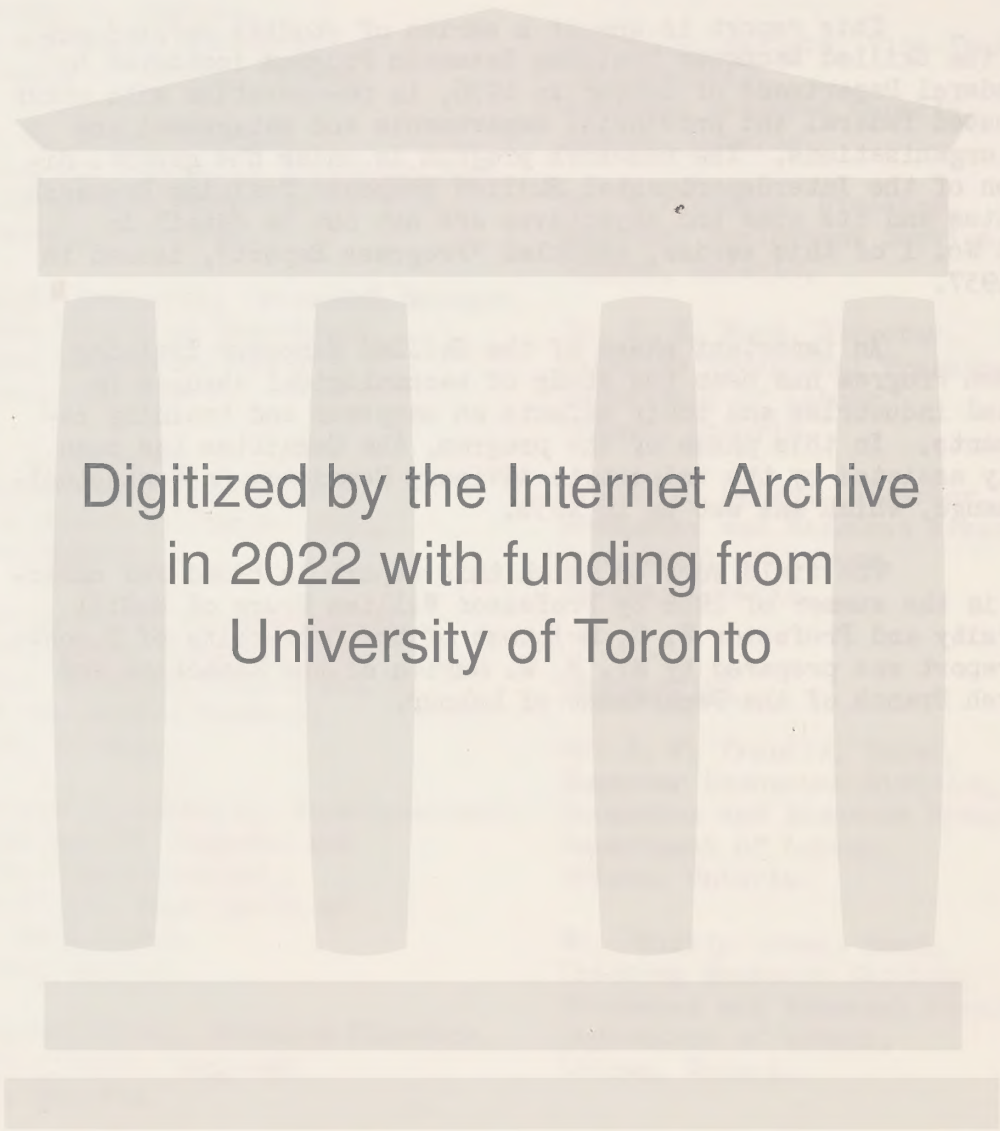


TABLE OF CONTENTS

THE TRAINING OF SKILLED MANPOWER

Research Program, Department of Labour, Canada,
in cooperation with other Agencies

Report 2: Technological Changes and Skilled Manpower: Summary Report on the Electrical and Electronic Industry and the Heavy Machinery Industry

I Purpose and Scope of the Research Program

The present study of the training of skilled and technical manpower, to which this report is one of many contributions, was started in the spring of 1956 by the federal Department of Labour in cooperation with provincial departments and other interested agencies. Such a study had been requested by the National Vocational Training Advisory Council, and the request was endorsed by the National Apprenticeship Advisory Council.

Shortages of skilled and technical manpower of various types have appeared in Canada fairly frequently during the last twelve years. In the case of some of the most highly qualified types, such as engineers and trained technicians, the shortages have been persistent.

The need for skilled and technical manpower in Canada will probably continue to grow rapidly. Increasing supplies of such manpower are essential to the continuing development of our industries and resources. Technological progress in industry, and the development of more complex weapons for the armed forces, further increase the demand for skilled and technical workers, and create demands for skills of new types.

Immigration has been, and still is, an important source of skilled and technical manpower. Relative to the increasing needs, immigration may, however, become less important as a source of supply in the future.

Informal in-plant training has also in the past provided a considerable percentage of Canada's skilled labour. It seems unlikely, however, to be effective in producing the higher types of skill which require more formal education, and for which there seems likely to be an increasing demand in the future.

The problem of training adequate supplies of qualified manpower in Canada in the future therefore requires thorough consideration. The present broad study, it is hoped, will help to provide reliable information to assist management, labour, government bodies, educational agencies, and the public generally, in reviewing and assessing the policies and actions which might best be taken in this important field.

Since substantial expenditures are involved in educating and training skilled manpower, it is important to review present programs to ensure that present and future expenditures by industry and government, on both a local and national basis, are used in the most effective manner.

Commencing in the summer of 1956, several initial research projects have been carried on, to obtain some of the basic information required for the overall study. These projects were intended to cast light on such questions as the definition of terms, the skill requirements of industry and the changes in these requirements resulting from technological and other changes, the present sources of supplies of skilled and technical manpower, the ways in which skills are at present being acquired, and existing institutions providing vocational and technical training.

Project I, of which the present report is one of the first results, is an investigation of the effect of technological and other changes on occupational requirements for skilled and technical workers, the existing sources of supply of such workers, and the types of in-plant training provided to develop the required qualifications in employees.

The required information was obtained through interviews with members of the management of representative firms in several selected industries. The industries selected were some of those in which rapid technological changes had occurred or were expected to occur. The present report summarizes the information obtained on the Electrical and Electronics Industry and the Heavy Machinery Industry.

II The Electrical and Electronics Industry

1. Characteristics of the Industry

This industry has been characterized by rapid growth in the past, and it is probable that its growth will continue to be rapid in the future.

The growth of the industry is closely related to scientific and technological progress. Especially in electronics, the complexity of the products has been increasing rapidly and new products have constantly been developed.

Among the chief stimuli to the technological progress and growth of the industry have been the Second World War and the postwar defence effort. Radar, radio, electronic controls, and other electrical devices have played an increasingly important part in modern weapons systems.

The development of television and other consumer products, in which important improvements continue to be made, has been another factor of obvious importance in the growth of the industry.

Electrical equipment for industry - including electronic calculators and control systems for automatic processes - is increasing in complexity, and is demanded in steadily increasing quantity.

The rapid growth of these varied markets, and the simultaneous technological progress, explain the rapid growth of the industry over the last twenty years. Between the pre-war peak year of 1937, and 1955, the physical volume of production of the group of industries described as "Electrical Apparatus and Supplies" increased four fold. Over the same period, the total volume of production in manufacturing in Canada expanded about two and one-half times. Such a calculation is obviously a very broad one. It does not indicate the important changes in products which have occurred over the period.

A considerable part of this growth occurred during the Second World War. However, between 1947 and 1955, the physical volume of production of the "Electrical Apparatus and Supplies" group increased by nearly two-thirds, and that of total Canadian manufacturing by a little more than one-third.

Employment increased between 1947 and 1955 by 44 per cent in the "Electrical Apparatus and Supplies" group and by 14 per cent in total manufacturing. Physical output per worker, therefore, increased during these eight years.

Total employment in the "Electrical Apparatus and Supplies" industrial group in 1955, according to the Census of Manufacturing, was nearly 76,000, or almost 6 per cent of total employment in manufacturing.

Measured either by employment or by gross production about 97 per cent of the industry is located in Ontario and Quebec. About one-quarter of the industry is in Quebec and almost three-quarters in Ontario.

Turning from past trends to the future, it was forecast by some of the officials interviewed that the output of the industry would approximately double in the next ten years. This does not appear impossible, since it would represent roughly the continuation of past trends.

It was also predicted that a considerable part of production in 1966 would consist of new electronic products not now made. This would also be consistent with past experience.

It is reasonable to expect further new developments in all three types of product with which the industry is concerned: defence products, consumer goods, and industrial equipment. It would be difficult to predict, however, whether these three markets will have the same relative importance in the future as in the past.

2. Effects of Technological Changes on Manpower Requirements

As has just been mentioned, the products of the industry are constantly becoming more varied and more complex. This applies especially to defence and industrial equipment, but also to some extent to consumer goods, of which a prominent example will probably be colour television sets.

The problems in designing products are becoming more complex. For this work, there is in consequence an increasing demand for highly qualified engineers, engineering assistants, and draftsmen. At all these levels, educational requirements are gradually increasing, and there is a demand for people with more intensive formal training over a broader field, which may include such subjects as physics, mechanics, chemistry, or metallurgy, as well as electricity and mathematics.

Theoretical training is more important in this industry than in some others, because of the nature of the products. The operation of an electrical circuit cannot be seen with the naked eye, but can be understood only by means of theory.

Production problems are also becoming more complex, as more complex designs call for closer tolerances and stricter quality control. There is an increasing demand for qualified personnel to plan production, to carry out time study and methods analysis, and for inspection and testing.

The expanding market for many products, especially consumer goods, results in the improvement of mass-production methods and a greater use of automatic processes.

Full automation is unlikely to be introduced quickly into the Canadian electrical and electronics industry, according to some of the officials interviewed. The chief effect of automation on this industry is more likely to be an effect on the demand for its products, due to the gradual spread of automation in other industries, which will require increasing quantities of electronic calculators and electronic and electrical control equipment.

Without proceeding to full automation, however, production in the industry is becoming more mechanized to supply the growing mass markets. One result of this is a shift in manpower requirements from emphasis on the skilled or semi-skilled production worker to emphasis on the engineers,

technicians, and more highly skilled tradesmen required to plan, install, and maintain the new more highly mechanized production facilities.

Research is increasing in importance. The need for research in Canada is still small in the case of some mass-produced products, for which the designs are produced by parent firms in the United States or Europe. In some cases, however, imported designs must be adapted by the Canadian subsidiary firm for the use of the Canadian market.

Products which are not mass-produced, but custom-built - chiefly defence materials and industrial equipment - must of course, be designed, and in the case of complex products this may require considerable research.

New products, of course, can be developed only as the result of research.

One or two of the men interviewed pointed out the importance of developing industrial research in Canada, as only thus can the Canadian industry hope ever to compete on equal terms with the industries of other countries. Although many branches of the Canadian industry are still closely dependent on parent firms elsewhere, there is some tendency toward greater Canadian self-sufficiency: at present, many products and components, which were formerly imported, have begun to be made in Canada.

The further development of industrial research in Canada will obviously depend upon the availability of an adequate supply of qualified scientists, engineers, and technicians.

To sum up: it appears likely that during the next ten years the greatest relative increases in manpower needs in this industry will be for professional workers, especially engineers, for technicians, for draftsmen, and for some types of highly skilled tradesmen.

It was suggested by some of those interviewed that the number of engineers required in Canada might double in the next ten years. While this seems to be a high rate of increase, it is not greatly different from the rate of increase during the past decade.

On the other hand, the absolute number of new engineers required in the next ten years, to maintain such a rate of increase, would be about double the absolute number added in the past decade.

The demand for unskilled and semi-skilled workers seems likely to become relatively less. However, it does not seem likely that the demand for workers of these categories will decline absolutely, if the demand for the products of the industry continues to expand as at present expected. Total employment cannot, of course, be expected to grow as rapidly as total output, since production per man-hour is certain to continue to increase.

3. Current Sources of Skilled Manpower

The three key groups with which we are concerned are professional engineers, technicians, and skilled tradesmen. These three groups differ considerably in training and presumably also in ability. There is only a limited amount of mobility between them.

The chief sources from which the industry obtains these three types of worker are as follows:

(a) Professional engineers:

These are normally either graduates of Canadian universities with degrees in engineering, or immigrants who have received equivalent higher education in their countries of origin.

A certain number of men without university degrees, but obviously possessing exceptional ability, are able to work up through the technician class and achieve the status of professional engineer (P. Eng.) by passing written examinations set by the professional engineers' associations of the various provinces.

(b) Technicians:

This group is ill defined, and covers a considerable variety of jobs of different kinds. In general, a "technician" might be defined as a person who, while not professionally qualified, is capable of filling a non-professional job which requires more formal education and more theoretical knowledge than is required of the ordinary skilled tradesmen. Adequate formal education in mathematics, science, as well as in English or French is especially important.

Persons fitting this definition are at present only occasionally graded officially as "technicians" by the firms employing them. They may be called "engineering assistants", "technologists", or by other names.

As defined above, the category of "technician" covers a wide variety of jobs, and a considerable range of ability and education. For purposes of illustration, some types of worker which might be included in the "technician" category are listed as follows:

(i) Engineering assistant, doing much of an engineer's work in research, development, design of products and tools, etc. This is the highest class of technician, and persons in this class have usually had substantial formal education beyond the matriculation level. Top men in this class sometimes, with some further training, achieve the status of "professional engineer".

(ii) Laboratory assistant. This term might cover a considerable range of skill.

(iii) Expert worker on inspection, testing, and quality control. This class overlaps "laboratory assistant", as the latter overlaps "engineering assistant".

(iv) Highly trained repairman, usually servicing complex equipment.

(v) Draftsmen of the top grade, working on design and possessing considerable mathematical knowledge, might be included in the "technician" category.

(vi) Skilled tradesmen of the top grade would be described as "technicians" by some employers.

While there is considerable room for argument as to which types of worker should be included in the "technician" category, there can be no doubt that the category as a whole is growing in importance, and that the number of "technicians" employed in the electrical and electronics industry has grown startlingly in recent years, and will grow rapidly in the next decade.

There is no predominant organized source of supply for technicians, such as the universities provide in the case of engineers. In general, firms hire the best people they can get, from the point of view of formal education, training, and ability, and raise them to the technician level by further intensive training in the plant. Frequently in Canada, a technician is a man who has acquired exceptional qualifications chiefly by his own efforts, without the benefit of a high level of formal education.

The chief sources of technicians for the industry, omitting trained men hired from other firms, which means no net addition to the supply, appear to be as follows:

(i) Technical institutes of the type of the Ryerson Institute in Toronto and the Institute of Technology in Calgary; Junior matriculation is required for entrance purposes to these institutes. The course provides a combination of practical work and theory with an emphasis on the latter. The graduates of these institutes are further developed to a high level by in-plant training. They are, however, few in number in comparison with the demand, although there are several higher technical schools in Canada in addition to the two mentioned, and a few more are now being organized. The majority of those graduating as electronics technicians or as electrical engineering technicians are absorbed each year by a few of the larger firms.

(ii) Technical courses in secondary schools: Graduates with matriculation, especially in mathematics and science, are good prospects, especially as they are likely to have the ability to absorb the specialized in-plant training necessary to qualify as technicians.

(ii) Cont'd

Persons who have left school before achieving matriculation require longer periods of training, possibly including night school or other further education. It seems probable, however, that many technicians come from this category, because of the shortage of those with better educational qualifications.

(iii) Persons trained in the Armed Forces: This is an important source of supply, but ex-service personnel are said by some of those interviewed to have been trained in relatively narrow fields, and therefore to require further in-plant training.

(iv) Immigrants: Some of these have been highly trained in Europe.

For the smaller firms especially, immigrants seem in some cases to form the chief, or almost the only, source of technicians of the higher grades.

The larger firms have highly-developed training schemes of their own, and also obtain the majority of the better trained Canadian youth. For smaller firms, in-plant training schemes are more costly, because of the probability of losing trainees to other firms. Immigrants thus become the chief source of technicians.

While immigrants are also important as a source of professional workers and of skilled tradesmen, they are perhaps most important, relatively to the total demand, as a source of higher-level technicians.

On the other hand, emigration to the United States is a constant drain on supplies of technical manpower. Several firms complain of the tendency of immigrants, especially those with professional qualifications, to use Canada as a bridge to the United States.

Draftsmen perhaps require special comment at this point. While they probably do not, except at the top level, fall into the technician category, they do in some cases require more formal education than is required for skilled tradesmen. Some firms prefer youth who have obtained their senior matriculation for training as draftsmen, although it seems

unlikely that they could obtain enough of these to satisfy their requirements. Some firms prefer entrants from technical courses at high school to those from other high school courses. Many trained draftsmen are obtained from England.

(c) Skilled tradesmen:

A man skilled in one of the traditional trades (electrician, machinist, etc.) requires as a rule less formal education and less theoretical knowledge than a technician.

A skilled trade is acquired through apprenticeship or in-plant training. Some of the larger firms have highly-developed systems of apprenticeship within the plant. While they would probably prefer to obtain entrants who had obtained senior matriculation to enter their apprenticeship courses, it seems unlikely that many of these are available for this purpose. Those who become skilled tradesmen have usually less than a full high school education.

Immigrants also are an important source of skilled tradesmen. Relative to Canadian tradesmen, the immigrants may in some cases have more formal education.

Skilled tradesmen in fact are often promoted to foremen or supervisors, but less frequently move into technician or engineer positions because of lack of formal education.

4. Current Shortage of Skilled Manpower

(a) Engineers:

While some firms consider that the shortage of engineers is not serious, most firms report that there is a significant shortage, especially of top-quality design and systems engineers, and some consider this the most serious of existing manpower shortages.

The extent to which a firm is affected by this shortage depends on the nature of its products, the rate at which it is expanding, how many new products it is developing, and how far it carries on original research and original designing.

The shortage of engineers is often said to be intensified by the employment of engineers as top executives, as salesmen, and in work which could be done by engineering assistants.

Efforts are being made by many firms to secure or train more engineering assistants, and in some cases to use arts graduates as salesmen.

(b) Technicians:

Nearly all firms report a shortage of technicians, and a few may consider this more serious than the shortage of engineers.

Practically all firms would like to get more graduates of post secondary technical institutes. In some firms, the great majority of technicians recently hired are immigrants.

In many cases, the number of technicians employed has increased since 1950 by a considerably larger percentage than the number of engineers, and in many cases employment forecasts for the next ten years show a greater percentage increase in technicians than in engineers.

Some firms employed practically no technicians six years ago. Many now state that they would like to employ 3 or 4 technicians for each engineer.

The recent apparent rapid increase in technicians may be due in part to more accurate classification of jobs.

(c) Skilled Tradesmen:

While some firms forecast considerable increases in employment in some skilled trades, and one or two state that standards of skill are rising, none complain of a really severe shortage of skilled tradesmen at present.

In some firms in the electronics industry, skilled tradesmen are not required in such large numbers as in some other industries, so that it is relatively easy to obtain the number needed from the labour market. The situation may therefore be different in some other industries.

5. Training in industry

As a general rule, a firm does not seem inclined to go to the expense of training personnel as long as it can satisfy its requirements by other methods. Training in industry results from necessity.

Nevertheless, because of technological developments and shortages of experienced personnel, the industry is becoming increasingly aware of the importance of training, and a great variety of training is provided by many firms for all the grades of manpower now being discussed:

(a) Engineers:

The larger companies at least provide substantial training courses for graduates in engineering, business administration, etc. during their first year with the company. Such courses cover design, manufacturing, marketing, and other subjects related to the individual's work for the company.

Engineers are also frequently given short courses on new types of equipment and other new developments; they are frequently sent to the United States or the United Kingdom for such ad hoc courses.

(b) Technicians:

The training provided in industry for technicians appears to be much greater in quantity, more varied, and more basic than the training given graduate engineers. This reflects the present lack of an overall system for training adequate numbers of technicians in Canada.

The type of training which each firm provides depends upon the qualities it requires in its technicians and the type of person it is able to obtain for training.

Top-level technicians are usually those who begin by graduating from a technical institute (after finishing high school) or who have had some university training, or who have been trained intensively in Europe. Such people are usually hired at a higher grade than those with less qualifications, are given further training which is sometimes theoretical as well as practical, and are advanced to higher grades in accordance with their development.

Persons who have obtained senior high school matriculation or its approximate equivalent, must usually serve a four-year apprenticeship in the plant or a long period of on-the-job training before becoming technicians.

As has been mentioned above, a technician in some cases is a person of exceptional ability who has achieved a high level of skill largely by his own efforts and sometimes without a high level of formal education to begin with. However, a person who had left high school before achieving his matriculation would not be likely to attain the technician level without further formal education, perhaps in night school, in addition to training and experience in the plant.

Draftsmen apprentices are taken on with various levels of education, up to senior matriculation. The level of previous education affects the type of training given and the grade to which the draftsman eventually rises.

(c) Skilled tradesmen:

Since persons with high school matriculation or technical institute training usually become technicians or university graduates, the skilled tradesmen are drawn chiefly from those with less education.

These people are usually interested in earning a living at an early age, and therefore obtain their training through some type of "earn while you learn" scheme. This means apprenticeship or some equivalent type of in-plant training, possibly supplemented by night classes or some

other type of formal training. Attendance at courses outside the plant is usually financed in whole or in part by the company.

Most of the larger companies have had systems of apprenticeship in many trades for many years. Some companies provide equivalent training on a less formal basis. Some smaller companies have found apprenticeship systems too expensive, chiefly because of loss of trainees, and prefer to rely on the local labour market for skilled tradesmen.

6. Suggestions from firms regarding public educational institutions and other topics:

(a) More university graduates:

It was suggested by one or two of those interviewed that there should be greater federal aid to higher education, and that universities should operate throughout the year, perhaps in two shifts of six months, to increase the supply of professional workers.

(b) Alterations in engineering curricula:

It was suggested that graduates in engineering should have a broader training than that presently given. Also greater emphasis should be placed upon attaining proficiency in written and oral expression. More advanced courses in mathematics and the sciences are desirable but taught from the standpoint of applicability to all engineering fields rather than directed towards one specialty.

(c) More technical institutes:

The proposal most widely supported was the establishment of many more highly technical institutes. Nearly all firms would like more people with this type of training. Such private schools as the Radio College of Canada were frequently praised as a source of technician material, but were thought to give a narrower training than available at a technical institute.

(d) National Certificate for technicians:

A few executives were in favour of the establishment of a National Certificate for technicians, or some equivalent system, to guarantee standard qualifications. It was observed, however, that the holders of the U.K. National Certificate do not all come up exactly to the same standard, as much depends on the individual's experience.

Growth of Employment in Selected Manufacturing Industries, Canada, 1929-1956

Year	Machinery[a]	Electrical Apparatus and Supplies	Total Manufacturing
	(Thousands of Employees)		
1929	12.4	20.9	666.5
1933	6.3	11.8	468.7
1939	12.2	20.3	658.1
1943	28.2[b]	46.9	1,241.1[b]
1944	26.7	48.8[b]	1,222.9
1946	27.0	44.0	1,058.2
1947	29.9	52.7	1,131.8
1948	30.0	53.9	1,155.7
1949	30.1	55.9	1,171.2
1950	29.9	60.3	1,183.3
1951	34.2	67.6	1,258.4
1952	34.7	69.2	1,288.4
1953	34.1	76.9	1,327.5
1954	32.9	75.1	1,268.0
1955	32.5	76.2	1,290.0
1956 (projected)	37.0	84.0	1,360.0
	(Percentage Change in Employment)		
1939 to Wartime Peak	131%	140%	89%
Wartime Peak to 1956	31	72	10

a. Includes industrial machinery; machine tools; and household, office, and store machinery.

b. Wartime peak of employment.

Source: Annual Census of Manufacturing, DBS. Figures according to Standard Industrial Classification.

III The Heavy Machinery Industry

1. Characteristics of the Industry

The products of the heavy machinery industry are sold chiefly to other industries to be used in making further products. In addition to this, the heavy machinery industry receives some Government orders, e.g. for heavy defence equipment, electrical equipment, and atomic energy equipment. However, the chief effect on the industry of government expenditures is the resulting increase in demand for machinery and equipment for other industries engaged in defence production, in the construction of public works, and so forth.

The types of machinery and related equipment which are produced may be divided into two broad categories:

(1) Electrical: e.g. motors, generators, transformers, communication equipment, electronic calculators.

(2) Non-electrical: e.g. turbines, boilers, diesel engines, machine tools, castings, structural steel, and specialized machinery for many industries such as oil refining or pulp and paper.

Some of the firms producing heavy machinery also produce consumer goods, such as washing machines or television sets. These products, however, are usually produced in separate divisions of the plants, and the present report need not be much concerned with them.

Mass-production methods cannot be applied to the production of industrial machinery in most cases, as large numbers of identical units are not usually required. Exceptions are certain standard items such as electric motors and meters, diesel engines, and, of course, the consumer products just mentioned. But a large proportion of the output of industrial machinery represents custom work.

Geographically, the industry is highly concentrated. Of non-electrical industrial machinery, over one-half is produced in Ontario, and about one-third in Quebec (measured by numbers of employees, according to the Census of Manufacturing). Of heavy electrical machinery, over 90 per cent is produced in Ontario. Of miscellaneous electrical apparatus and supplies, a little more than one-half is produced in Quebec, and a little less than one-half in Ontario.

The growth of the industry has been rapid since 1939. It is evident, however, that fluctuations of employment in the economy as a whole are likely to be reflected in magnified form in the production of machinery. In 1933, for example, employment in the machinery industry had fallen by nearly one-half from its 1929 level, and even in 1939 employment was not quite as high as it had been in 1929.

Between 1939 and 1943, however, employment in the industry more than doubled. This was the effect of the demands of war-production. Nevertheless, the wartime peak of employment was exceeded by 1947, and from 1951 to 1956 employment has averaged about 20 per cent higher than the 1943 peak figure.

The continued growth of the machinery industry since the end of the Second World War has been due to the rapid growth of Canadian industry in general, and the high rate of investment in new machinery and equipment in Canada which since 1951 has amounted to approximately two billion dollars per year, or about 8 per cent of the Gross National Expenditure.

The future growth of the industry depends upon a number of factors, especially the following:

1. The quantity of industrial machinery requiring replacement annually, due to depreciation or obsolescence. This replacement demand is likely to grow approximately in proportion to the overall growth of the total stock of machinery employed in Canadian industry.

2. The anticipated increase or decrease in the total volume of production in Canadian industry during the next few years is one of the chief determinants of the volume of production of machinery and equipment during the current year. The anticipated rate of growth of production in the economy is the resultant of two factors:

(a) the long-run trend,
(b) cyclical movements.

As previously mentioned, any anticipated increase or decrease in the rate of growth of total production is likely to have a magnified effect on production in the machinery industry. For example, an increase of 10 per cent in anticipated total production for the next five years might result in an increase of, say, 50 per cent in the production of machinery (and vice versa).

3. Technological progress seems likely to provide additional stimulus to the growth of the machinery industry. By increasing output per capita and income per capita, it calls forth new products and new industries to satisfy new demands; in many cases, new demands for industrial machinery will result. The increase in output per worker will call for the use of more machinery per worker and the continuous substitution of machinery for human workers.

In addition, improvements in the machines themselves will tend to increase the rate of obsolescence of old machinery. This will increase the replacement demand.

Improvements in machinery will tend to increase output per unit of machinery, and this will tend to slow down somewhat the increase in demand for machinery. It seems probable, however, that the net effect of technological progress will be a substantial increase in the rate of growth of the market for industrial machinery.

4. Various economic factors will also affect the machinery industry. One such factor will be the trend of imports of machinery. This has been one of Canada's leading imports for many years. As the Canadian economy grows, however, it might be expected that imports would provide a smaller percentage of Canada's total requirements of machinery.

As a result of the various influences which have been mentioned, it seems probable that the growth of the heavy machinery industry in future might be more rapid than the growth of Canadian industry in general. This relationship would be reversed temporarily if a period of serious depression should occur.

The Royal Commission on Canada's Economic Prospects has stated that, in the absence of any such serious depression, "it seems possible that Gross National Product may triple in real terms over the next quarter century". The heavy machinery industry, in such a case, might be expected substantially to exceed this rate of growth.

2. Effects of Technological Changes on Manpower Requirements

Only the most general idea can be given here of the nature of the technological changes taking place in the heavy machinery industry. One important type of technological change is the development of new products, including, for example, equipment for the development of atomic power, varied types of electronic equipment, such as radar devices and electronic computers, and more efficient or more automatic types of machinery.

Other changes are directed at the improvement of the quality of established products. Constant effort in this direction is necessary to meet competition. It is necessary, for example, to work to closer tolerances, and to explore the possibilities of new materials, such as improved alloys.

A third type of technological change is the improvement of methods of production. There is little scope at present for the introduction of automation into the heavy machinery industry, since mass-production is possible only for certain standard items, and even these are not produced in sufficient quantity in Canada to make full automation economic. However, processes are becoming more highly mechanized, and some automatic machines are being introduced. Changes in plant organization, as output has increased, have sometimes resulted in lower costs.

The technological changes in progress are resulting in an increase in emphasis on certain functions, and consequently in a relative increase in the demand for certain types of employee. Among the functions which are receiving increased emphasis are the following:

(i) Design is absorbing relatively more effort. The increasing complexity of products, the development of new products, the closer tolerances required, and the increasing mechanization of the production process, call for more elaborate and more precise designs, and the preparation of more detailed drawings. More of the work is being done by the designer, and less is left to the skilled production worker. In an industry engaged largely in custom work, the effort which must be devoted to design is correspondingly great.

(ii) Research is increasing in Canadian industry. Designs and techniques are still frequently imported from parent firms in the United States or in Europe, but this applies to mass-produced items rather than to heavy machinery. Research is desirable, from a broad point of view, in order that new products may be developed, and in order that Canadian industry may become more independent of the industry of other countries. But from a more immediate point of view, research is required into new products, new materials, and new methods of production, in order that a firm may not fall behind its competitors in the processes of technological change.

(iii) Inspection and scientific quality control are absorbing a greater proportion of the manpower employed. Responsibility for the quality of the product is being transferred from the skilled production worker to the inspection staff and the laboratory. Techniques of quality control are becoming more complicated, involving in various cases statistical quality control, X-ray inspection, ultrasonic testing, optical colimators, hardness testers, etc. The level of education required in the inspection staff is consequently rising.

(iv) Methods analysis and production planning are becoming more important as products and processes become more complex and more varied. This is another case in which some of the work of the skilled production worker is being taken over by specialists. Work in methods and planning requires personnel who have both theoretical knowledge and experience in the plant.

(v) The laboratory is becoming more important, because of its contribution to the four functions just mentioned. Control of design, quality and methods is passing from the production line to the laboratory.

As a result of the processes of technological change which have been briefly outlined, the quality of products is being improved, and output per man-hour is increasing. As already mentioned, there are also changes in the relative demand for different types of employee.

For the purposes of the present discussion, six types of employee may be distinguished:

1. The engineer or scientist
2. The technician
3. The draftsman
4. The skilled tradesman
5. The semi-skilled worker
6. The unskilled worker

The first four of these are the key groups, since they require prolonged training and may at times be in short supply. These four groups differ considerably in training and ability, and there is only a limited amount of mobility between them. The chief point of difference between them may be stated as follows: the engineer or scientist requires considerably more formal education than the technician, and the technician requires considerably more formal education than the skilled tradesman, while the draftsman requires a specialized type of training which may be carried to a fairly high level.

The groups which appear to be required in relatively greater numbers, as a result of present technological changes, are the first three: the engineer or scientist, the technician, and the draftsman.

The increasing emphasis on research, design, quality control, and methods analysis, obviously requires the professional services of an increasing number of engineers. The increasing complexity of the products, and the increasing application of science to industry, also make the engineer more valuable in such other functions as management and selling.

A person trained in pure science may be required for specialized research, or may sometimes be employed on engineering work because of the shortage of engineers.

The increasing effort needed in design is increasing the demand for draftsmen, of whom, in consequence, some firms state that there is a shortage.

The case of the technician perhaps illustrates the present trend best of all. Technicians appear to be increasing in number more rapidly than any of the other categories. Unfortunately, it is difficult to be sure of this, because there is no definition of the "technician" which is as yet universally accepted. This category includes a wide variety of different types of work, and a wide range of skill and ability. Few firms have any employees who are officially classed as "technicians", but most have some employees whose work appears to belong to this category.

In general, a technician might be defined as a person who, while not professionally qualified, is capable of filling a job which requires more formal education and more theoretical knowledge than is required of the ordinary skilled tradesman. For purposes of illustration, some types of worker which might be included in the "technician" category have been listed above in section II.3.

While there is considerable room for argument as to which jobs should be included in the "technician" category, there is no doubt that the number of jobs, which reasonably could be so included, has increased rapidly in recent years, and is certain to continue to increase rapidly.

The skilled tradesmen, who constitute our fourth key group, have in some cases been in short supply in Canada in recent years. They do not appear to be one of the groups which is gaining strikingly in relative importance as a result of technological changes. But the overall expansion of the industry is probably increasing the absolute demand for skilled tradesmen.

In some processes, the degree of skill required of production workers is decreasing, as mechanization of the process makes it possible to substitute machine operators for the former craftsmen.

In some cases, skilled tradesmen, by receiving additional formal training, are able to qualify for technician jobs. The need of formal education, however, especially in mathematics and science, is a difficult

hurdle to overcome, and the more normal line of advancement for a skilled tradesman is perhaps to foreman and supervisor.

Some of the firms in the heavy machinery industry which were interviewed in 1956 complained of serious shortages of certain types of skilled tradesmen. It appears probable that the demand for this category or worker will continue to increase, although less strikingly than the demand for engineers, technicians, and perhaps draftsmen.

Semi-skilled workers, since they can be trained within a short time, are unlikely to be in short supply. While mechanization may in some cases increase the relative number of semi-skilled jobs in a plant, this type of job is also in some danger of being abolished by further technological changes. It does not seem likely that the percentage of semi-skilled jobs in industry will increase in the future.

The unskilled worker is still more likely to be replaced by a machine, and it seems possible that the demand for unskilled workers may decrease relative to the total demand for manpower.

The magnitude of the changes in the manpower requirements of the heavy machinery industry cannot be estimated at present. The number of engineers employed in the industry, judging by the statements of some of the officials interviewed, might perhaps double over the next ten years. The numbers of technicians and draftsmen employed might well increase by the same or a greater percentage.

These statements assume that output will continue to increase as now expected. However, for any future level of output, it seems reasonable to expect that engineers, technicians, and draftsmen will form an increasing percentage of the total working force employed by the industry.

3. Current Sources of Skilled Manpower

The four key types of manpower with which we are concerned are engineers, technicians, draftsmen, and skilled tradesmen. These are the most highly qualified types of industrial manpower, and the types in which shortages may occur.

There are four sources from which firms may obtain employees of these types:

(i) Immigration
(ii) Public or private educational or training institutions in Canada
(iii) Training schemes operated by the firm itself
(iv) Attracting qualified employees away from other employers.

The last method obviously does not increase the supply of qualified manpower, from a national point of view, and will therefore not be discussed here.

Immigration has been an important source of skilled and professional manpower during the last decade, and especially since 1951. Different firms appear to differ greatly in the extent of their reliance on immigration as a source of manpower. Some firms report that they are employing few immigrants, while others report that immigrants make up a large part of their skilled and professional working force, and may even form a majority of their technicians or their draftsmen.

Immigrants in some cases have received more thorough training as technicians, draftsmen, or skilled tradesmen than is generally available in Canada. Men holding the Higher National Certificate from the United Kingdom are especially highly regarded. By hiring such immigrants, a firm is able to avoid the cost of training equivalent workers in its own plant. It seems probable that large firms, which have highly-developed programs of in-plant training in many fields, rely less on immigration as a source of manpower than other firms do.

Immigrants are of course more mobile than natives, and the commonest complaint about skilled or professional immigrant workers is that they often use Canada as a bridge to the United States.

Canadian-trained personnel must usually receive a combination of formal education and in-plant training before they are fully qualified as engineers, technicians or draftsmen.

This is true even of professional engineers, although for these a university course forms the essential part of the training, and in-plant training consists merely of introduction to specific types of work, or to new products or new processes.

Most Canadian-trained technicians receive a large part of their training in the plant. This is partly because schools equipped to train technicians are not sufficiently numerous in Canada to satisfy more than a fraction of the growing demand.

The top-level technician, often called an engineering assistant, should have, according to management, a high level of education. He should have completed Grade 13, in high school, especially in mathematics and science. He should then have graduated from the Ryerson Institute or some institution of equivalent standing, such as the Montreal Technical School or the Radio College of Canada. He should then have intensive training in the plant.

Training in the armed forces may take the place of graduation from the Ryerson Institute, although the background thus acquired may be somewhat narrower.

Graduates of institutions of the Ryerson type are scarce. Some firms therefore hire boys with as much high school education as possible, and develop them into technicians by in-plant training, or apprenticeship usually combined with night-school courses financed wholly or partly by the firm.

The term "technician", as mentioned previously, can be used to cover a wide range of skill and training. While the "engineering assistant" requires considerable theoretical knowledge of science and mathematics, in some other cases there is greater emphasis on length of experience in the industry. A skilled employee of long service may become an inspector or a trainer of maintenance men, and can then be considered a "technician".

Some jobs, such as that of melter in a foundry, require considerable mathematical and scientific knowledge, and are physically arduous as well. Such jobs are understandably hard to fill, and the firm is likely to have to develop its own men to fill them.

The importance of immigrants with European training as a source of technicians is easily understood, in view of the scarcity of higher technical schools in Canada, and the cost to firms of providing equivalent training, in the plant and at night school, to their own employees.

For draftsmen also the range of skill is wide. A top-level draftsman, working on design, requires a knowledge of mathematics as well as of the product and the processes in the plant. This combination is found more often in draftsmen with European training than in Canadians.

However, some top-level draftsmen are produced by graduation from the higher technical schools, plus some in-plant training.

The more ordinary grade of draftsman is a person with some high school or vocational school education, who has received his practical training in the plant. Such a boy would require several years of training to reach the top grade.

Skilled tradesmen are produced usually in this industry by systems of apprenticeship or on-the-job training in the plant. Many Canadian skilled tradesmen, of course, have acquired their skill chiefly by experience on the job without systematic teaching. Some firms state that, as candidates for apprenticeship, they prefer boys who have completed Grade 10 or 11 (in Quebec) or even Grade 13. It seems unlikely that the supply of such candidates would be sufficient.

A final impression that emerges strongly, from the interviews held in this industry, is the desire of most employers for more employees with substantial formal education, for training as technicians, as draftsman, or as skilled tradesmen. Completion of Grade 13 in science and mathematics is frequently mentioned as the level desired.

4. Current Shortages of Skilled Manpower

The shortages referred to here are those existing in the summer of 1956, when interviews were conducted in this industry.

The most widespread shortages were in the most highly-qualified categories, that is, in top-level engineers and top-level technicians.

In addition, the shortage of draftsmen seemed to be very prevalent, especially of draftsmen with the highest qualifications.

The shortage of engineers is sometimes said to be intensified by the employment of engineers at work which is not fully professional, such as work in administration or sales, or work which could be done by an engineering assistant.

Among the types of technician, mentioned as being in short supply, were designers, inspectors, and experts on methods, work processing, and work planning.

Shortages of skilled tradesmen were also mentioned in the Heavy Machinery Industry more frequently than in the Electrical Industry. Among the types in short supply in some localities were welders, fitters, patternmakers, toolmakers, machinists, coil winders, and moulders and coremakers. These shortages appear to have been less prevalent in 1957 than in 1956.

5. Training in Industry

Training in industry results from necessity, and a firm is not inclined to undertake the expense of long courses of in-plant training, if it can satisfy its requirements by other methods.

In fact, however, a great variety of training is provided in industry, especially by the larger firms. Such training might be divided into two broad categories:

(i) Prolonged training in the elements of a certain type of work, to develop a supply of manpower of a type not otherwise available in adequate quantities: this category would include the apprenticeship courses provided to develop skilled tradesmen, technicians, and draftsmen.

(ii) Shorter courses of training given to people who already possess the basic qualifications for their work: this would include courses provided for newly-graduated engineers during their first year or two of employment with the firm, and courses on new products or new methods provided for engineers, technicians, or skilled tradesmen who have already been with the firm for some time.

The training given graduate engineers in industry, while it is of the second category, is nevertheless sometimes quite substantial. The specialized courses given to newly-hired engineers, fresh from the university, sometimes extend over two years. Engineers who have been employed longer are frequently sent to the United States or the United Kingdom for periods of training with parent firms in new technological developments.

To develop technicians, a large variety of courses are offered by different firms, because of the wide range of skills included in this category, and the high proportion of the supply of technicians which in Canada must be developed by the employers in their plants. These courses include various forms of apprenticeship, and also at the higher level advanced courses in mathematics, physics, etc.

Shorter special courses are also given to technicians, maintenance men, and others, to introduce them to new products or new methods.

Skilled tradesmen are trained largely by apprenticeship in many firms. In some cases, because of the relatively high level of education required of a candidate for apprenticeship, it seems probable that a young man who completes his apprenticeship will be a technician or a supervisor rather than an ordinary skilled worker, and that the majority of skilled tradesmen will be trained chiefly by experience on the job.

6. Suggestions from firms regarding public educational institutions and other topics

1. Education of Engineers: A few management representatives suggested that engineering students should receive more training in industrial management, or that some students should be trained in engineering plus management, and others in specialized branches of engineering.

2. Technician Training: Several of the men interviewed compared Canada's training methods unfavourably with those in the United Kingdom and Europe. Some stated that Canada needed a type of training similar to that which in the United Kingdom leads to the Higher National Certificate.

3. More Higher Technical Schools: A considerable number of interviewees favoured the establishment in Canada of more schools of the type of Ryerson Institute, for the training of technicians.

4. Apprenticeship: Canadian apprenticeship systems were criticised. Some suggested that better integration was needed between in-plant apprenticeship and school courses; one problem was the lack, in some localities, of technical schools close to the industrial plants.

It was also stated Canadian firms are too eager to hold onto the men they have trained; men who have completed apprenticeship should be encouraged to get experience in other plants. Unfortunately, in the few cases in which this has been tried, few men have returned later to the firm in which they served their apprenticeship, and this firm has therefore obtained little benefit from its apprenticeship system.